



## **FINAL REPORT**

# **BASELINE SURVEYS FOR DESERT TORTOISES (*GOPHERUS AGASSIZII*) AT THE MARINE CORPS LOGISTIC BASE, BARSTOW AND SURROUNDING CRITICAL HABITAT**

**January 07, 2007**

**For**

**Marine Corps Logistic Base  
Barstow, CA**

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Barstow, CA**

**January 07, 2007**

**Presented By**

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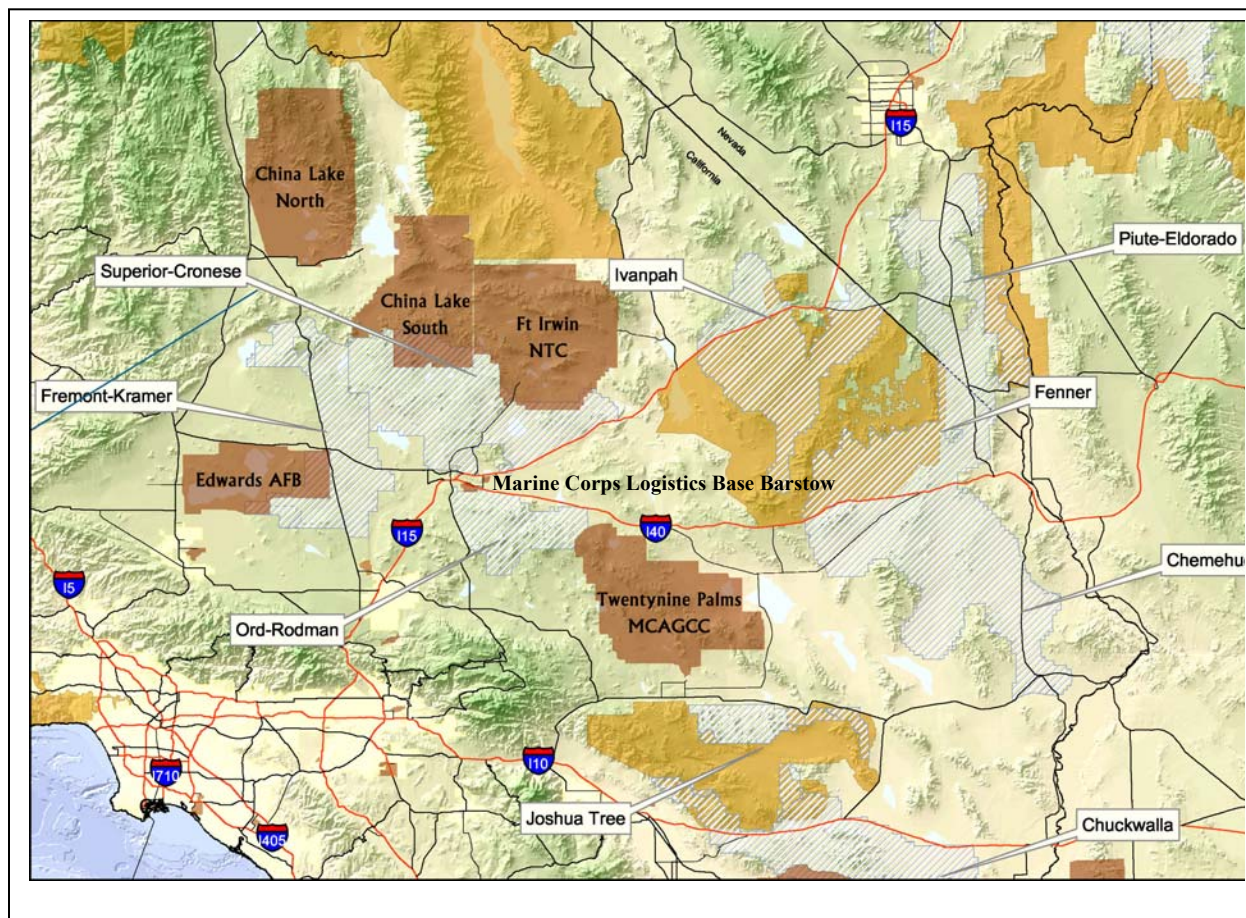
## **1. INTRODUCTION**

### **1.1 Distribution and Status**

The desert tortoise (*Gopherus agassizii*) is a large, semi-fossorial, terrestrial tortoise that inhabits desert ecosystems from southeastern California, southern Nevada, southwestern Utah, and northwestern Arizona south through the Sonoran Desert to eastern Sonora and northern Sinaloa, Mexico (Ernst et al. 1994). The desert tortoise was state-listed as threatened in California on 3 August 1989 (California Fish and Game Commission 1989), while the Mojave population of the desert tortoise living north and west of the Colorado River was federally listed as threatened on 2 April 1990 (55 Federal Register [FR] 12178-12191, U.S. Fish and Wildlife Service [USFWS] 1990a; USFWS 1990b). Some of the main reasons for listing the Mojave population of desert tortoises were loss of individuals to disease, severe climatic conditions, loss and degradation of habitat, increased levels of mortality associated with urban growth throughout the desert, and the inability of regulatory and management agencies to protect desert tortoises and their habitat (USFWS 1990a). Section 7 of the Endangered Species Act (ESA; 1973) requires that all Federal agencies conserve threatened and endangered species (TES), and in consultation with the USFWS or National Marine Fisheries Service (NMFS), ensure their actions are not likely to jeopardize the continued existence of any TES or result in the destruction or adverse modification of critical habitat. The California Endangered Species Act (CESA 1984, California Fish and Game Code Section 2050-2068) declares that all state agencies shall seek to conserve endangered and threatened species, while not approving actions that will “jeopardize the continued existence of any endangered or threatened species or result in the destruction or adverse modification of habitat essential to the continued existence of those species.”

Approximately 6.6 million acres were designated as desert tortoise critical habitat on 8 February 1994 in California, Nevada, Utah and Arizona (59 FR 5820-5866, USFWS 1994a, b). The majority of critical habitat is on Bureau of Land Management land (BLM, 74.3%), followed by private (17.0%), Department of Defense (DoD, 3.8%, pre-Ft. Irwin expansion), State (2.6%), National Park Service (NPS, 2.3%), and Tribal lands (0.02%; USFWS 1994a). Notable differences in desert tortoise morphology and genetics as well as regional variation in climate and habitat characteristics in the Mojave Desert (Luckenbach 1982; Rowlands et al. 1982; Lamb et al. 1989; Rainboth et al. 1989; USFWS 1994b; Peterson 1996a; Britten et al. 1997) led to further subdividing the Mojave population of desert tortoises into recovery units (Brussard et al. 1993; USFWS 1994b). Six recovery units were identified to represent the full spectrum of habitats, behaviors, genetics, and morphology of the desert tortoise. These recovery units provide workable areas in which specialized management recommendations are applied based on the different needs of each recovery unit. Each recovery unit is further subdivided into one to four Desert Wildlife Management Areas (DWMAs), totaling 14 DWMAs (USFWS 1994b). It is important to note that research conducted in one recovery unit may or may not be applicable or comparable to similar research conducted in other recovery units. Five major state and federal agencies are responsible for the management of desert tortoise populations and habitat within the Western Mojave Recovery Unit (WMRU; see Foreman et al. 1986): (1) BLM; (2) USFWS; (3)

California Fish and Game Department (CFGD); (4) DoD; and (5) the National Park Service (NPS). It is estimated that of the 37,969 sq km of land within the WMRU, 29,124 sq km (76.7%) contain suitable desert tortoise habitat (West Mojave Plan 1999). Approximately 63.0% of suitable tortoise habitat within the WMRU is federally owned, 35.4% is privately owned and 1.6% is state owned. DoD- operated lands account for 28.6% of the total land area within the WMRU (10,853 sq km); 67.3% of these lands are thought to be suitable as desert tortoise habitat (West Mojave Plan 1999). There are five (5) major DoD installations within the WMRU (Figure 1): (1) Naval Air Weapons Station, China Lake (4,585 sq km in size; installation size figures from Base Structure Report 2002); (2) the National Training Center (NTC), Fort Irwin (2575 sq km; pre-expansion); (3) Marine Corps Air Ground Combat Center (MCAGCC), 29 Palms (2,451 sq km); (4) Edwards Air Force Base (1,217 sq km); and (5) Marine Corps Logistic Base (MCLB), Barstow (25 sq km). The first four (4) installations have had numerous surveys and research projects conducted on their properties while the MCLB has been involved in only a couple of desert tortoise projects in the past. The results of one (1) of these studies showed that desert tortoises in the Mojave Desert are occupying steep slopes, a habitat type that they are believed not to occupy. The purpose of the current study is to provide additional information as to the general distribution of desert tortoises at the MCLB and to make some comparisons between their steep sloped population and that residing in the adjacent, more typical flat desert habitat.



**Figure 1. Department of Defense installations and Desert Wildlife Management Areas in the Western Mojave Recovery Unit in southern California (MDEP 2003).**

## **1.2 History of Survey Methodologies**

Surveys designed to estimate desert tortoise abundance and distribution have been pivotal in the more important legal, management and recovery strategies involving the desert tortoise. Two basic methods of study that have been employed: (1) the “transect study” - scattered sampling over broad regions to provide a general, but very imprecise, idea of tortoise abundance and distribution over the region; and (2) the “plot study” - an intensive coverage of a specific location in order to provide a reliable, quantitative estimate of tortoise density at that site. Each method has different goals and levels of effort and each provides a different level of reliability and usefulness.

Transect studies, as they have historically been conducted, offer only a general idea of the abundance of tortoises in an area. Because of numerous statistical and biological difficulties with the historic method, they have not reliably provided density estimates (the actual # of tortoises/unit area, as opposed to a general idea of abundance). So, while transects sample broad areas, the results to date have been only suggestive of tortoise abundance and are often incorrect. Dr. Alice Karl found that while conducting transects on the NTC, only 47 % of the density estimates from transects were approximately correct on sites where plot studies were ultimately conducted; there was no significant correlation of tortoise sign on transects to actual tortoise densities on the plots (Karl 2001).

The main problems with transects as they have been conducted to date is the low sampling rate (0.3-2 transects per section), not separating sign into groupings of type and tortoise size, the subjective counting or elimination of sign based on inter-sign distance, a fixed transect width, lack of accounting for either vegetation, substrate or topographical influences, and high variance during calibration on sites of known tortoise density (BLM trend plots). These factors have prevented transects from properly being used for their intended purpose: to predict tortoise abundance over broad regions. Appropriate changes in the sampling method and increased sampling effort will eliminate the sampling and statistical problems associated with past transect study design.

Plot studies yield density estimates (# of tortoises/unit area) and a measure of the reliability of those estimates (95 % confidence interval). The precision offered by plot studies is far higher than that for transect studies, but the costs are concomitantly higher, because only a very small area (e.g., 1 square kilometer) is studied in a labor-intensive fashion. Thus, the number of sites that can be sampled are many fewer than for transects.

In 2001-2005, a third method has been used in portions of the Mojave Desert to estimate broad regional tortoise abundance. This method, called line distance sampling, is designed to yield broad, regional abundance estimates and to be able to assess temporal trends in abundance over broad regions. However, it is still in an experimental stage for use on desert tortoises (cf. Medica and Burroughs 2001). One of the main problems with line distance sampling is the extremely large number of transects that must be walked in an area to meet the minimum statistically viable

number of tortoises. Rarely is this critical value of tortoises achieved, thus the validity of the results have been questioned.

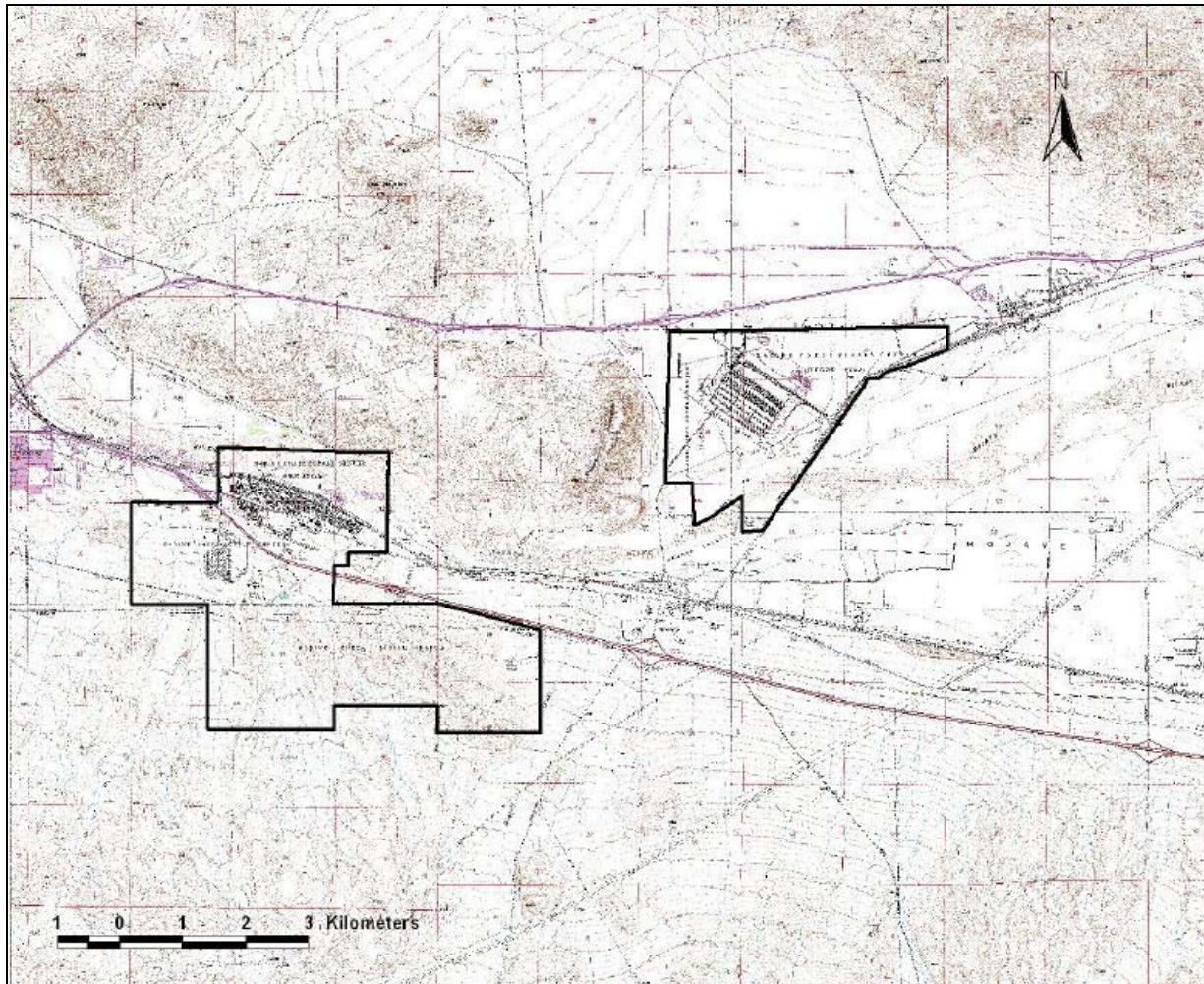
### **1.3 MCLB and Desert Tortoises**

The MCLB has desert tortoise critical habitat along the southern boundary of the base. This critical habitat is along the northern edge of the Ord-Rodman Desert Wildlife Management Area. Unlike most areas that have critical habitat designation that are relatively flat or gently sloped, the area at MCLB that is designated as critical habitat has extreme topographic relief and very steep slopes (Fig.2).

In 1997, the MCLB in collaboration with the NTC and the MCAGCC initiated a desert tortoise study to determine if desert tortoises occur on steep slopes. The results of the study indicated that desert tortoises do indeed occur on steep slopes and it was noted that at MCLB they occurred in densities that were equal to or greater than populations residing in more typical flat desert areas (Gardner and Brodie, 2000). This study had important management implications as desert tortoises are typically considered not to occur on these slopes, thus management and surveys need to take these areas into consideration. Furthermore, it has been noted that as the flat desert gets impacted by human disturbances such as off-road vehicles (ORVs) and development the tortoises are moving into the hilly terrain where such disturbances are limited. Little, if any, research has been conducted to assess tortoise behaviors, activity, foraging, or movement patterns in these steep slope areas. Before any such studies can be conducted an understanding of tortoise distribution must be conducted across MCLB, and surrounding lands.

### **1.4 Technical Objectives**

The technical objectives of this study are to: (1) survey land for the presence of desert tortoise sign (scat, burrow, carcasses, and live tortoises) at the MCLB and the adjacent BLM properties, and (2) to make a comparison of desert tortoise densities between two habitat types; steep slopes and flat desert. The goal is to establish maps of each of these sign characters, as well as cumulative sign variables, to illustrate desert tortoise relative abundance across the surveyed landscape. The results of the plot surveys will provide much needed information as to desert tortoise densities on steep slopes with a comparison to adjacent flat desert areas. While not an objective of this proposal, observations of desert tortoises for health parameters, and assessment of carcasses, may reveal information on the overall health of the population at the MCLB.



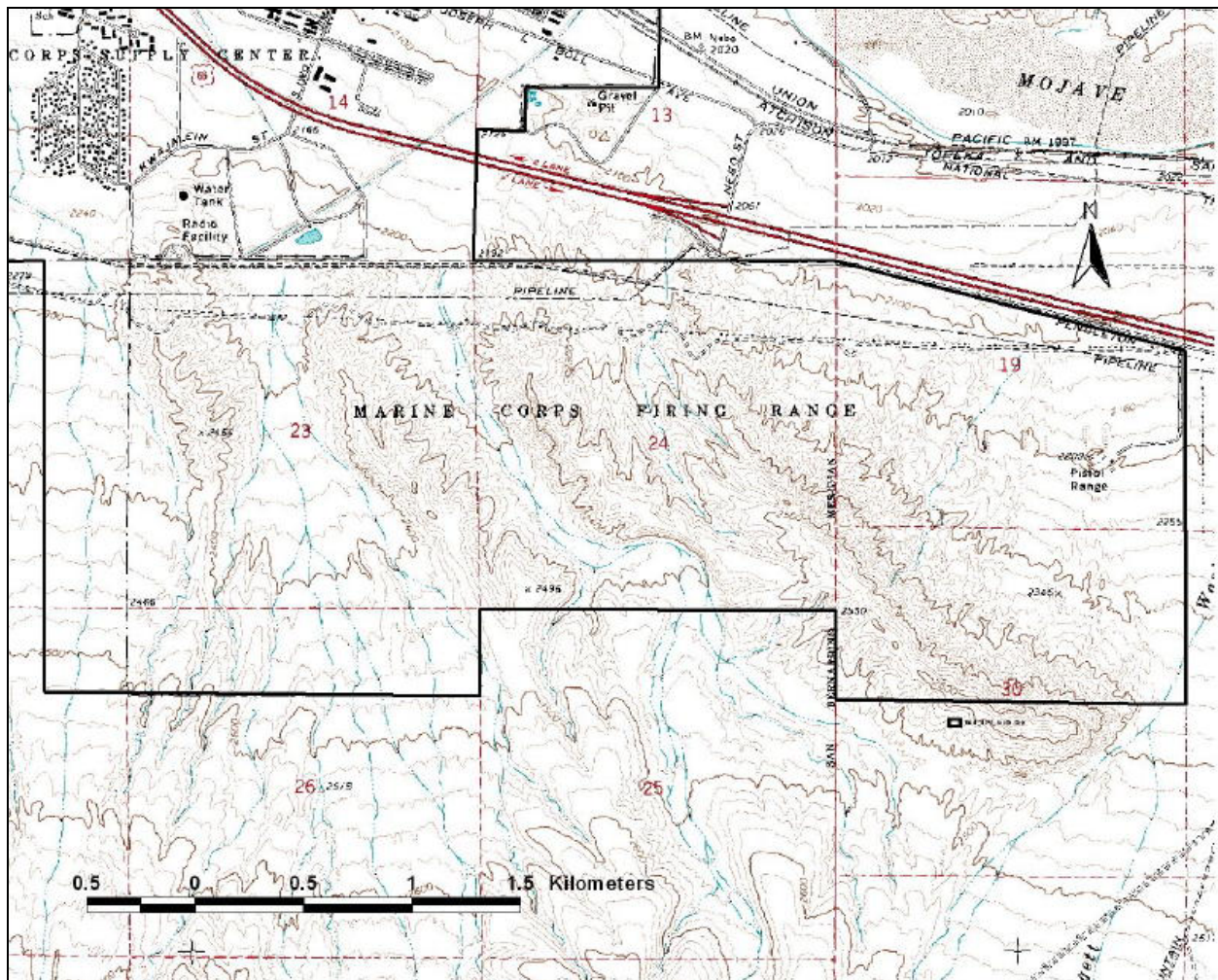
**Figure 2. Map of the Marine Corp Logistics Base, Barstow showing the three parcels that comprise the base. Desert tortoise critical habitat is found along the southern portion of the western parcel and extends south and east into the Ord-Rodman Mountains.**

## **2. METHODS**

### **2.1 Location of Study**

The MCLB is comprised of several relatively distinct pieces. The area that we are in reference to with regards to these surveys is the area known as the Rifle Range [Marine Corps Firing Range] (Figure 3). However, for the intent of this survey, the northern portion has been impacted by utility right of ways and access roads, therefore we will not survey north of these disturbances. Thus, an area on the MCLB roughly 5.25 km by 1.6 km was surveyed. As a reference point and for use of comparison an equal area was surveyed south of the MCLB, as well as a small portion east of the base, these areas are designated as critical habitat and are primarily owned by the BLM. Therefore, the entire area surveyed by transects was 6 km by 3.2 km, demarking the western boundary of the survey area with the western property line of the MCLB and the

northern point being the utility right of way. There is reasonable access to this entire survey area from the eastern side of the MCLB, Daggett Wash, and Ord Mountain Road.



**Figure 3. Southern Parcel of the Marine Corps Logistic Base, Barstow, detailing the area referred to as the Rifle Range.**

## 2.2 Tortoise Surveys

We conducted time constrained transect surveys searching for desert tortoise sign which includes; scats, tracks, burrows, carcasses, and live tortoises. Surveyors walked in a west-east then east-west survey pattern starting at the northern most point (the utility corridor) and working their way south. Transect locations are presented in figure 4, and were spaced 100 meters apart (latitude). All tortoise sign was recorded with the use of a PDA synced to a GPS unit. The use of PDAs greatly reduces data entry time and reduces transcriptional error. Transects were numbered for ease in data collection and management purposes. Multiple transects, approximately 10, were walked on each square kilometer. Transects were conducted from August through October, coinciding with the maximum accumulation of tortoise sign and low tortoise movement patterns. This high rate of transects should provide data for a highly accurate

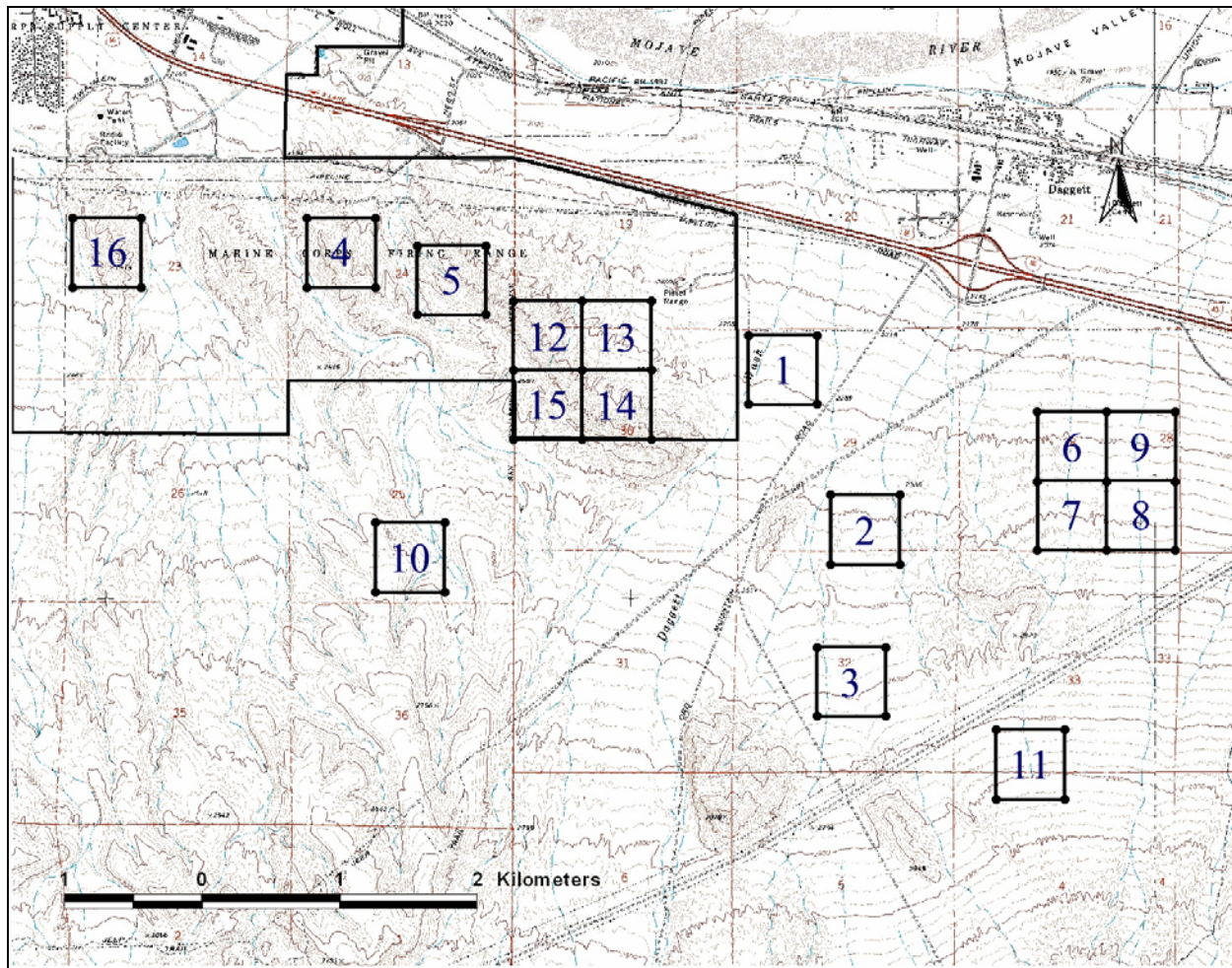
The map displays a topographic view of a coastal region in southern California. A grid of 20x20 points is overlaid on the map, with the central area labeled "MARINE CORPS FIRING RANGE". The grid is bounded by a thick black line. The map includes contour lines, roads, and various geographical features. A scale bar at the bottom indicates 2 Kilometers. A north arrow is located in the upper right corner.

As a separate part of the study we conducted plot surveys to assess differences in densities of desert tortoises between two different habitat types; steep slopes and flat desert. We surveyed 16, 500m by 500m plots, with survey transects spaced 10 m apart. Eight (8) plots were done in

the steep slopes and eight (8) in near-by flat desert. Figure 5, shows the locations of the plot surveys that sample representative areas of each habitat type. All tortoises captured during the surveys had standard measurements taken and a small dot of nail polish placed on the marginal scutes distinguished them as having been surveyed. This type of plot survey required the surveyors to make two passes to ensure that every animal gets marked. To ensure that closed population estimators could be used (statistically more robust), the two passes were made immediately after each other.

During both types of surveys tortoise sign classification systems were used. We used a simplified scale as the objective was to determine general distribution. A burrow classification system was used to quantify age of the burrows, generally described as: burrow category 1 being a burrow that was distinctively desert tortoise with signs of recent use, burrow category 2 being a burrow that was used this year but shows no signs of recent use, burrow category 3 is a burrow that is identifiable as belonging to a desert tortoise but has not been used during the past year. An additional burrow category, caliche den, refers to burrows that are formed in caliche layers; these are difficult to assess as belonging to desert tortoises and thus were only included if desert tortoise sign (scat, tracks, etc.) was observed.

The purpose of the transect surveys was to assess tortoise distribution. It was not the intent of these surveys to capture, measure, and mark live tortoises. However, observations of tortoises in and out of their burrows did allow for coarse assessment of size, sex, and sometimes health status. Therefore, we utilized the size class categories for desert tortoises that have been defined by Turner and Berry (1984) and utilize measurements of midline carapace length (MCL); Juvenile 1 (<60 mm), Juvenile 2 (60-99 mm), Immature 1 (100-139 mm), Immature 2 (140-179 mm), Subadult (180-207 mm), Adult 1 (208-239 mm), and Adult 2 (>240 mm). Adult and subadult tortoises were sexed using presence or absence of male secondary sexual characteristics, males exhibiting longer, thicker tails, plastral concavity, wider and more heavily scaled forearms, and longer, more curved gulars. Tortoises that were classified as subadult or adult that did not exhibit male secondary sexual characteristics were considered to be females. Data for carcasses included size class category, sex, etc. where applicable; in addition, the time since death was estimated using keys developed by Berry and Woodman (1984) and Alice Karl (personal communication).



**Figure 5. Location of survey plots for comparative study of desert tortoise densities in flat desert (plots 1, 2, 3, 6, 7, 8, 9, 11) to steep slopes (plots 4, 5, 10, 12, 13, 14, 15, 16).**

### 2.3 Required Authorizations

Research on rare, threatened, or endangered species that are state or federally listed requires permits of authorization from the appropriate managing agencies. The desert tortoise is state and federally listed and therefore required permits from the CAFG and the USFWS. Additionally, part of the survey effort was on BLM lands therefore a permit was required from them as well. Prior to the initiation of surveys permits from all three agencies were acquired.

### **3. RESULTS**

Surveys were separated into the two different tasks, plot surveys and transect surveys.

#### **3.1 Transects**

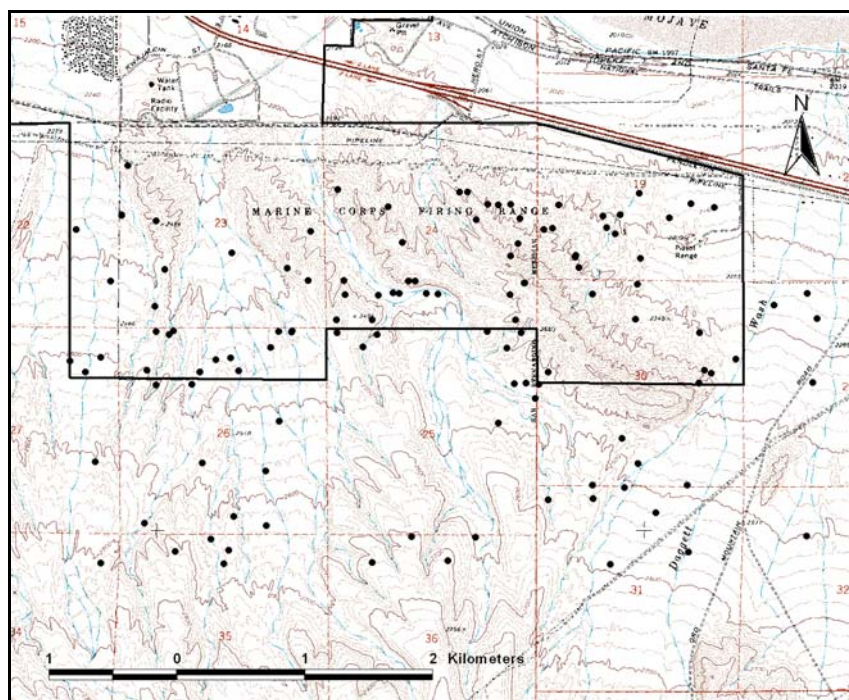
Transect surveys were conducted between 21 August and 17 October 2006. It was initially proposed that 160-200 transects, one (1) km in length may be conducted. A total of 187, one (1) km transects were completed, as well as four (4), 0.5 km transects, for a total of 189 km of transects (Figure 4). These “short” transects were a necessity due to disturbances, roads, houses, and other impacts near the northeastern proposed transect area.

The purpose of the transect surveys were to provide a general overview of tortoise sign distribution across the Rifle Range at the MCLB as well as an approximately equal area south of the base on BLM lands. Desert Tortoise sign that was surveyed for included scats, tracks, burrows, carcasses, and live tortoises. While we include scats and tracks in the sign while we are surveying it is generally acknowledged that they are difficult to observe. Tracks can only be left in soft soils; therefore results are immediately biased towards area capable of displaying such sign, typically washes. The observation of scats are highly dependent upon searchers abilities, openness of the habitat (shrub layer and annuals), annual biomass during the year, and substrate type, as scat is hard to see in rocky/pebbly areas and more obvious in flat desert with a fine to medium sandy substrate. Therefore, no scat or track data will be presented.

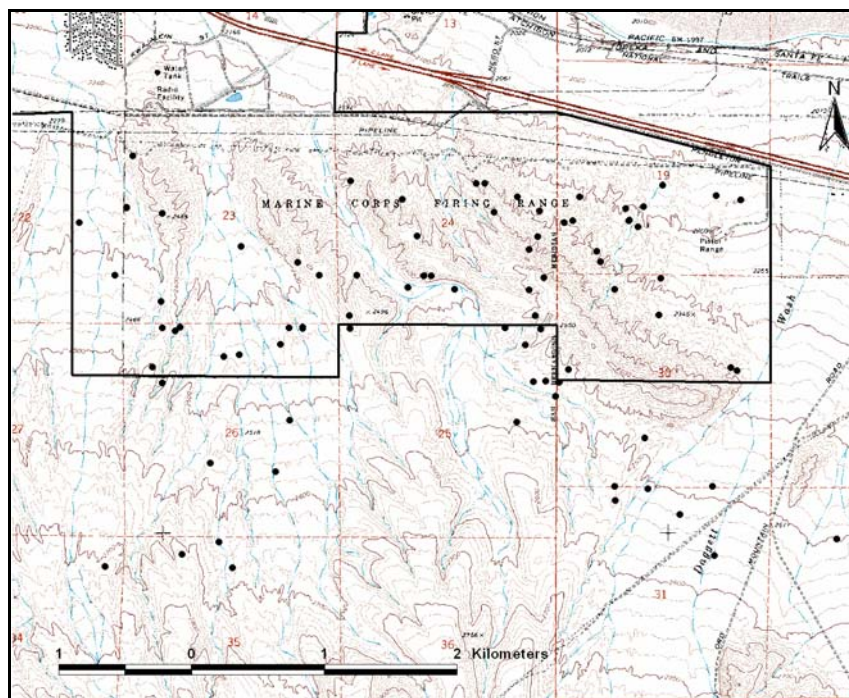
A total of 124 burrows was observed during the transect surveys (Figure 6a). Twenty-eight percent (n=35) of these burrows showed sign of recent use, while an additional 31 % (n=38) had been used this year. In addition to these active burrows, caliche dens that had signs of tortoise use represented 10 % (n=12). Thus, 68.5 % of all burrows observed during the transect surveys showed signs of use during the past year (Figure 6b). The remaining 31.5 % (n=39) of burrows observed were old desert tortoise burrows that showed no sign of use during the past year. A total of 23 live tortoises were observed on transects (Figure 7). Carcasses were the most abundant sign observed on transects with a total of 138 carcasses observed (Figure 8).

The purpose of the transect surveys were not to assess population structure but simply to assess tortoise distribution. A calculation known as Kernels that is used to estimate home range of animals can be adapted for use in mapping utilization distributions (or probabilities of encounter) of animals. Fixed Kernel utilization distributions using least squares cross validation as a smoothing parameter were created for burrows used in the last year (Figure 9), live tortoises (Figure 10), and carcasses (Figure 11).

a.



b.



**Figure 6. Location of burrows observed during the transect surveys. a) Shows all burrows regardless of age, b) burrows that were considered to be used by a tortoise in the past year.**

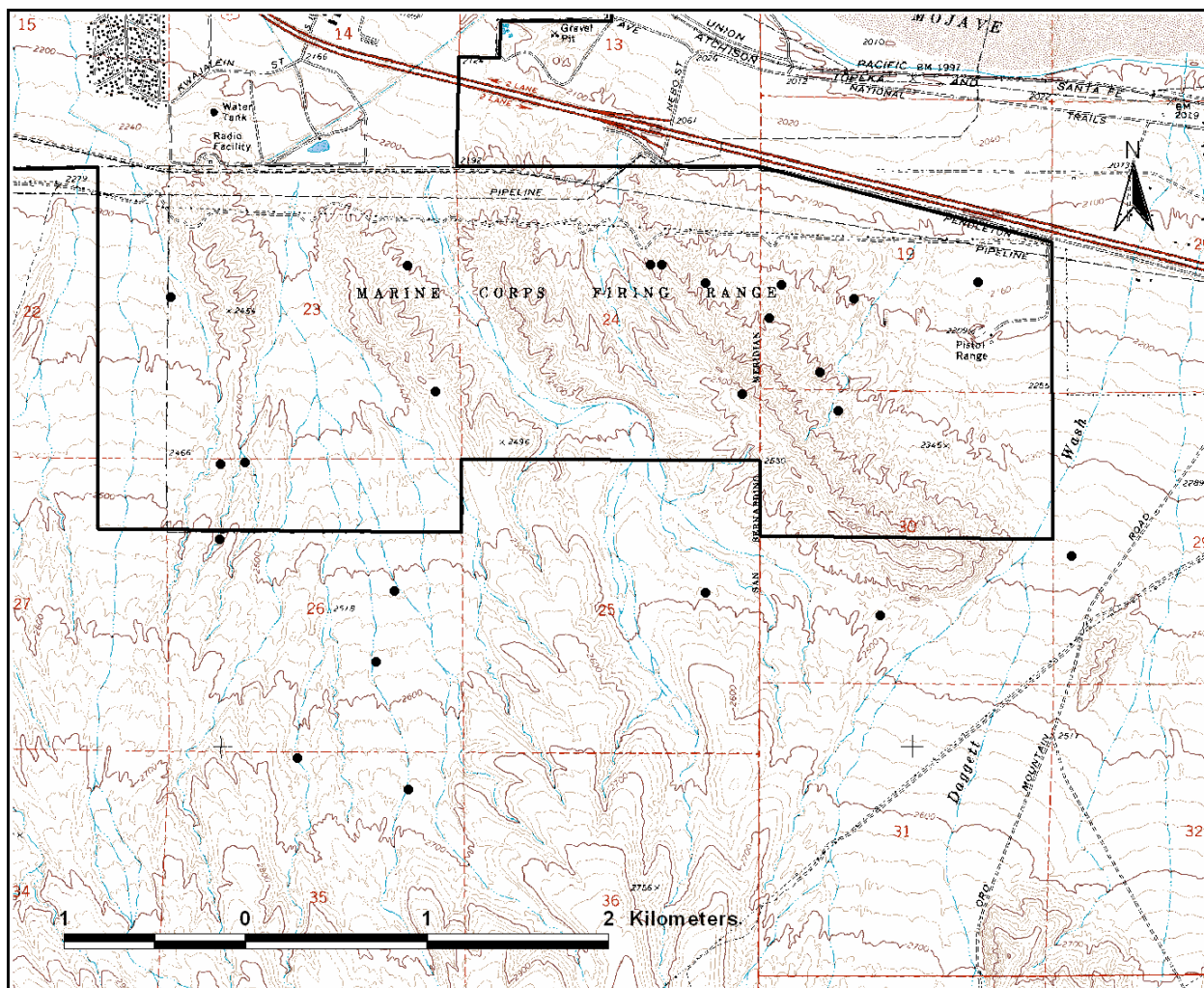


Figure 7. Locations of live tortoises encountered during the transect surveys.

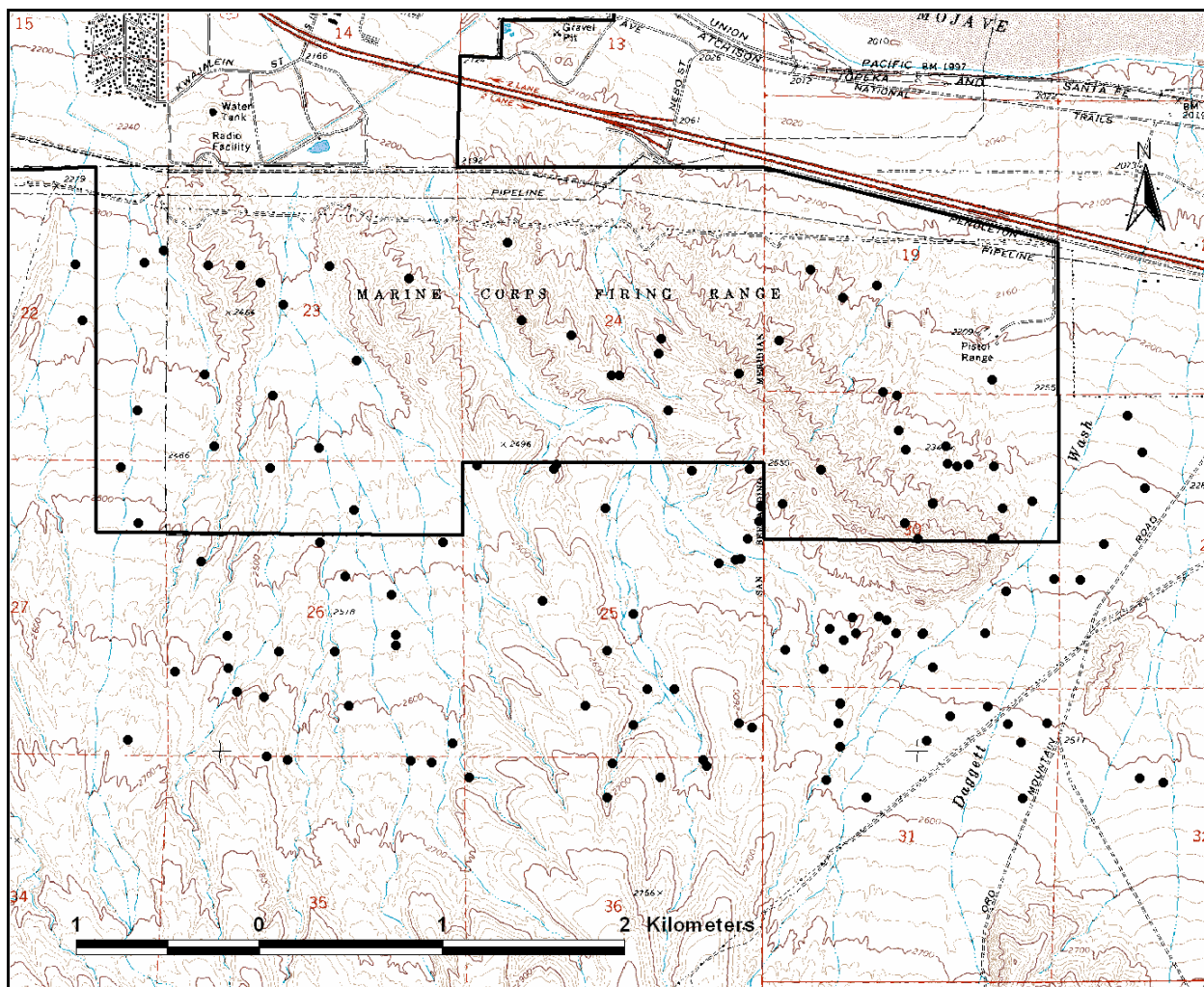
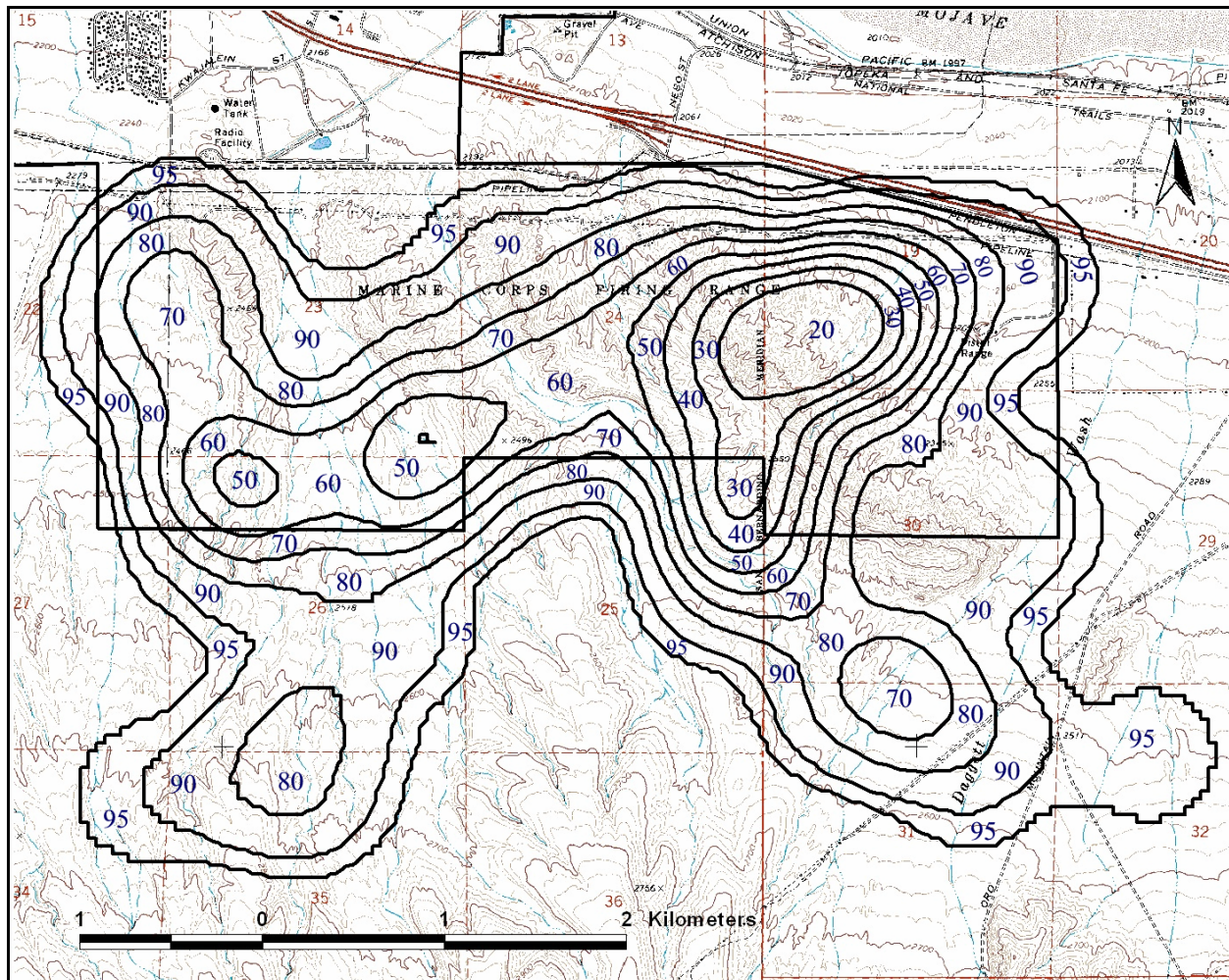
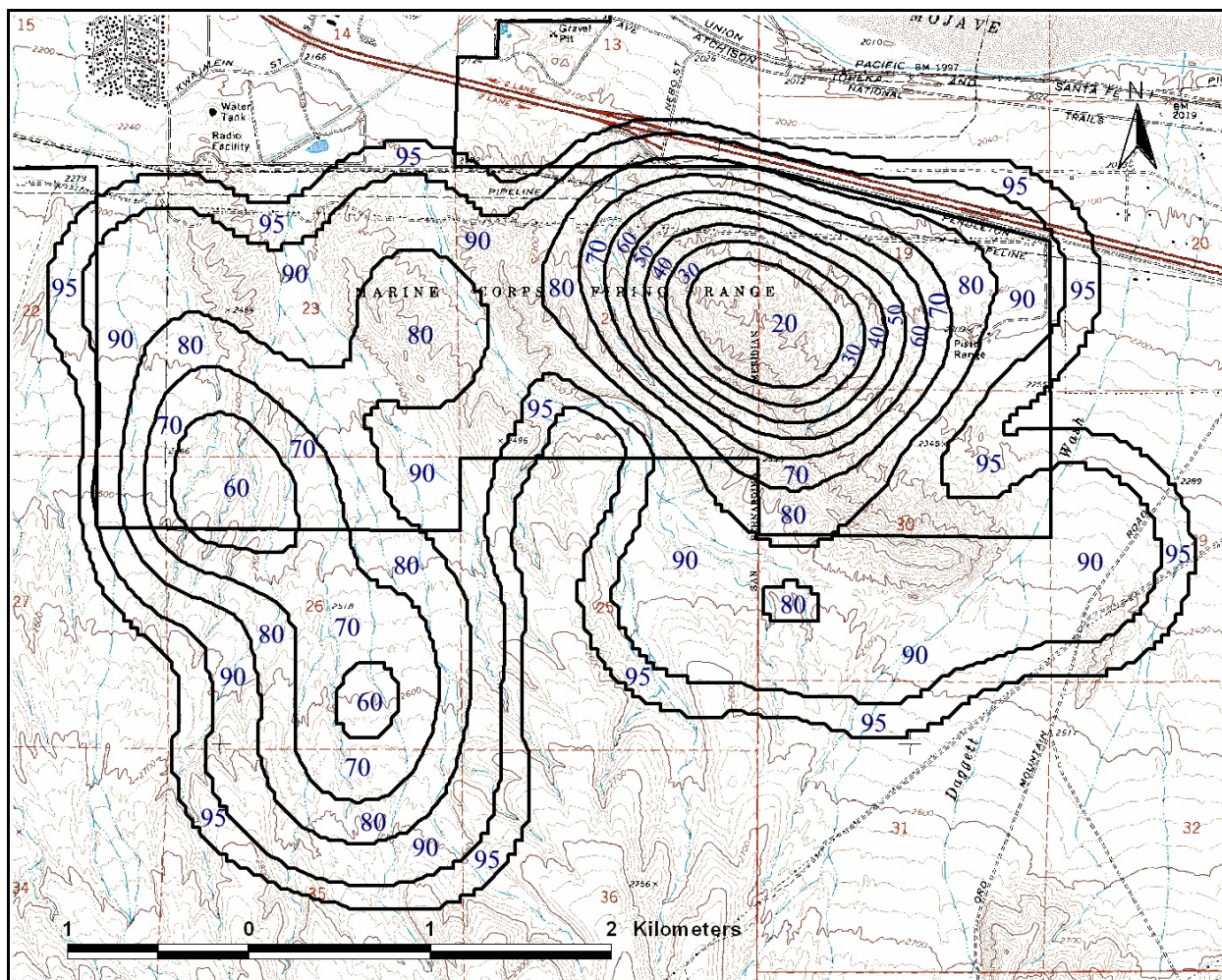


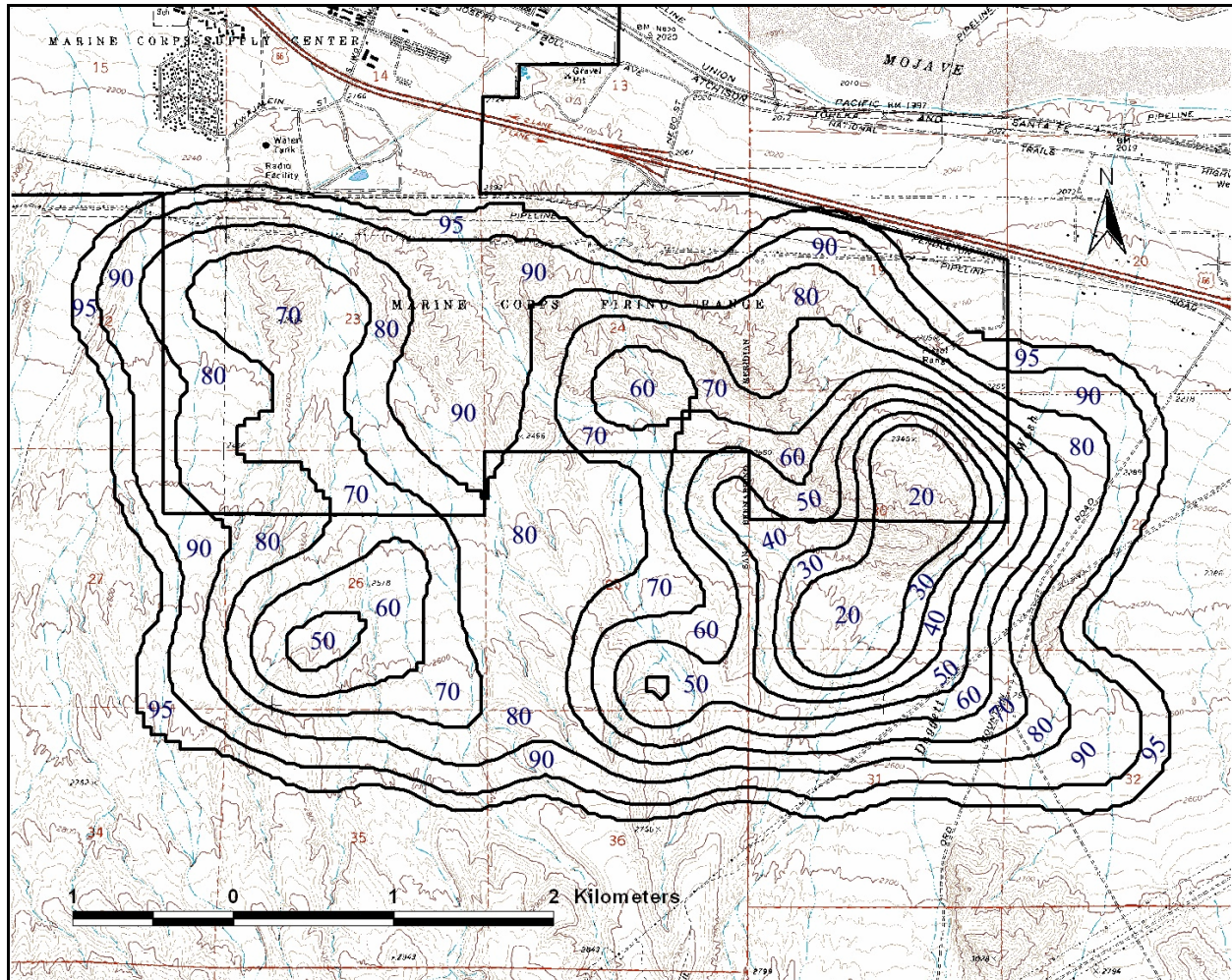
Figure 8. Locations of carcasses observed during transect surveys.



**Figure 9. Fixed kernel utilization distributions of desert tortoise burrows considered to be active in the past year observed while conducting transect surveys. Numbers and contours are probabilities.**



**Figure 10. Fixed kernel utilization distributions of live desert tortoises observed while conducting transect surveys. Numbers and contours are probabilities.**



**Figure 11. Fixed kernel utilization distributions of desert tortoise carcasses observed while conducting transect surveys. Numbers and contours correspond to probabilities.**

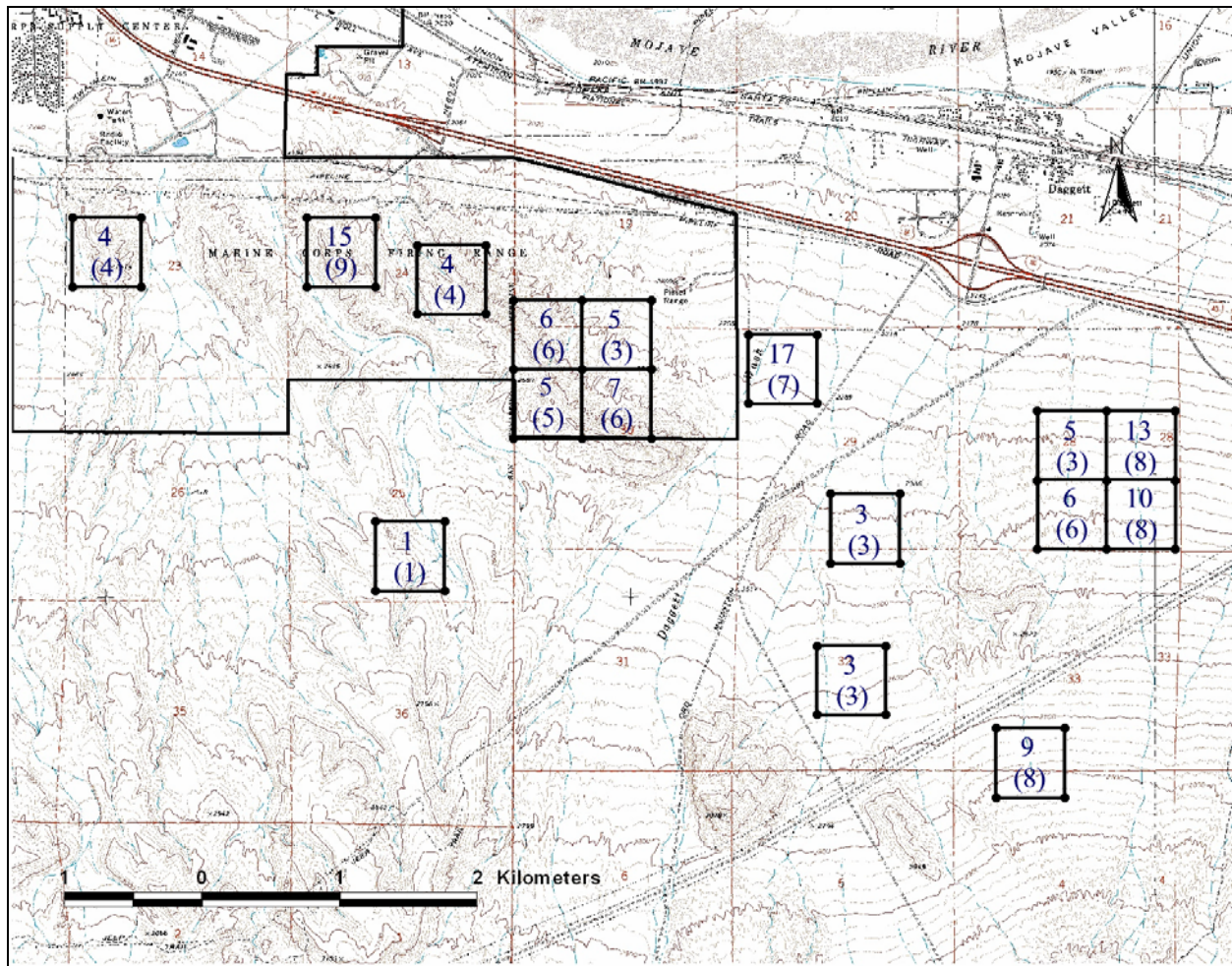
### 3.2 Plots

#### 3.2.1 Plot Survey population estimates

Plot surveys were conducted between 5 September and 12 October 2006. One pass of one plot was typically completed in one day allowing for the “recapture” survey to occur the next day. Those that took slightly longer were completed the following day. The short duration between capture periods should be small enough to allow for the use of closed population estimators which are more reliable and accurate than open estimators.

A total of 16, 500x500m plots were completed, eight (8) in flat desert and eight (8) in steep slopes (Figure 5). Flat desert plots included plots 1, 2, 3, 6, 7, 8, 9, and 11. Steep Slopes plots included plots 4, 5, 10, 12, 13, 14, 15, and 16.

The purpose of the plot studies was to determine actual densities of desert tortoises and their sign, as well as morphometric comparisons between the two plot types, flat desert and steep slopes. A total of 80 live tortoises was observed on all plots with 43 observed on the flat plots and 37 in the steep sloped plots. There is no significant difference in the number of live desert tortoises observed on the different plot types. Population estimates were calculated from each mark-recapture for each plot (Figure 12), however numbers in this figure add up to more than our “observed” live tortoises. This is due to the fact that some tortoises were marked in a plot and then found during surveys in the adjacent plot. As we were treating each plot as a separate survey effort we included those “recaptured” tortoises as “new” tortoises for the purpose of population estimates. This scenario presented itself with one (1) tortoise in the steep slope plots and three (3) in the flat desert plots. Flat desert plots had an average population estimate of  $8.25 \pm 4.98$  tortoises per plot, with a range of 3-17. Steep slope plots had an average population estimate of  $5.88 \pm 4.09$  tortoises per plot, with a range of 1-15. There was no significant difference in population estimates between the flat desert and steep slope plots ( $U=22.0$ ,  $p>0.05$ ). Due to low numbers of animals actually encountered, primarily due to a large die off in the area in which the plots were conducted, the population estimates are at best weak. Therefore, we investigated if actual live tortoises encountered between flat desert and steep slopes differed. There is no significant difference in the number of animals observed between the flat desert and steep sloped plots ( $U=25.5$ ,  $p>0.05$ ). Thus we can conclude that desert tortoise populations are equal, showing no difference in population densities between flat desert and steep slope plots.



**Figure 12. Population estimates for each individual plot. Numbers in brackets are the actual number of live tortoises observed on each plot from both passes combined. Some animals were caught on more than one plot; because each plot is treated as a separate survey effort these animals are treated as new individuals in these cases.**

### 3.2.2 Morphometrics Plot Surveys

Comparative analysis of morphometrics and health of live animals encountered between plots reveal some slight differences between plot types. In general, comparisons of morphometrics of adult tortoises (>180mm MCL) are similar between flat desert and steep slopes (Table 1). There were no significant differences between mass or size (MCL) when females and males are compared separately between flat desert and steep slopes. However, as can be seen when the data is broken down by size classes and sex for each plot type, flat desert (Figure 13a) and steep slopes (Figure 13b), the flat desert plots data are skewed towards larger individual while the steep slopes have a more even size class distribution. As is typical with the sexually dimorphic desert tortoises, males are larger than females, which is also evident in the data (Table 1, Figure 13a,b).

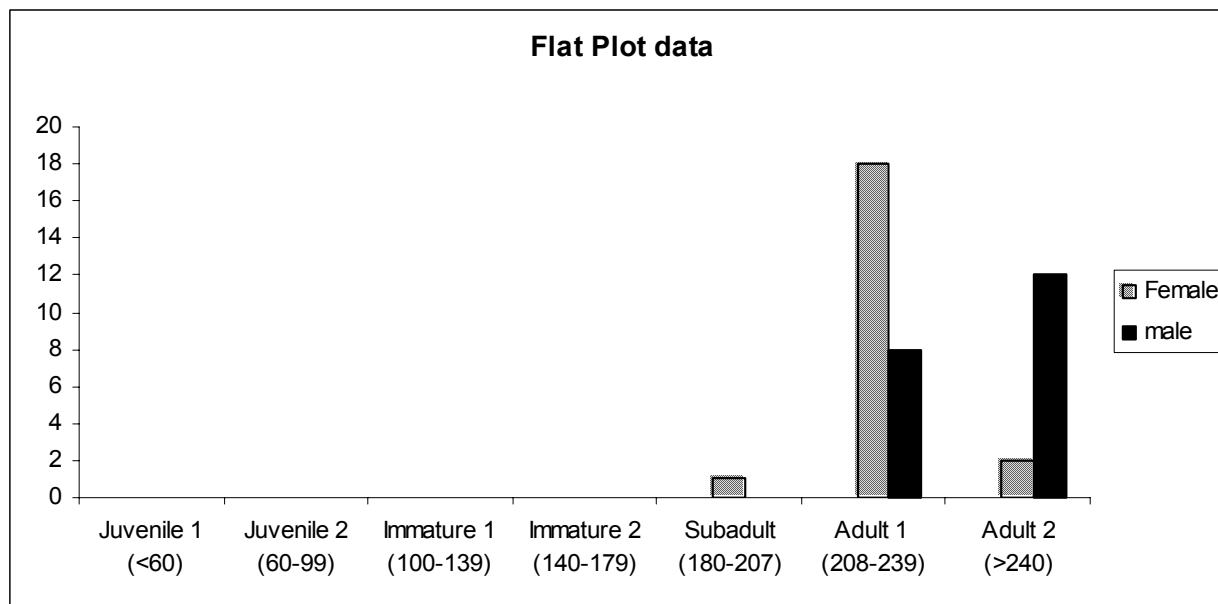
**Table 1. Comparison of mass and mid-line carapace measurements of adult desert tortoises located in flat desert or steep slopes by sex.**

	Flat Desert Plots		Steep Slope Plots	
	Female (n=21)	Male (n=20)	Female (n=16)	Male (n=18)
Mass (g)	1975 ± 373 (1440 – 2975)	2584 ± 699 (1680 – 4400)	1883 ± 367 (1160 – 2450)	2545 ± 1105 (1000-4350)
Mid-line carapace (mm)	222.9 ± 13.19 (204 – 254)	245.5 ± 20.01 (211 – 298)	220.7 ± 15.00 (190 – 244)	239.2 ± 38.16 (181 – 291)

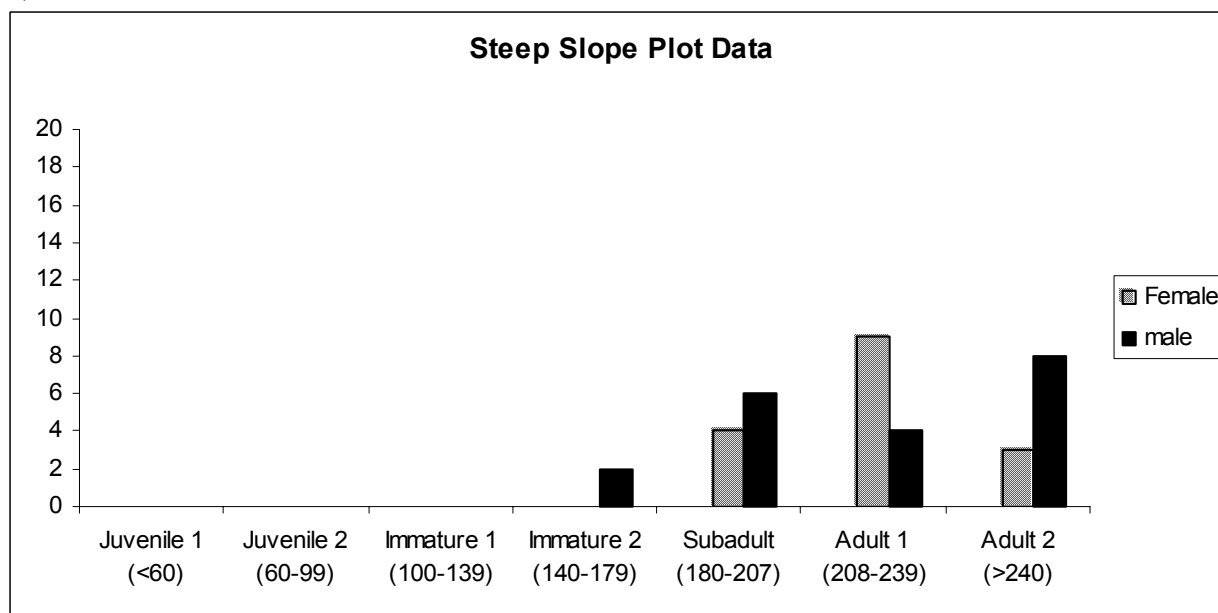
### **3.2.3 Health Assessments Plot Surveys**

Basic observational health assessments were made of tortoises when possible, some tortoises did not come out of burrows while others remained pulled into their shells. As it was not the intent of this project to conduct extensive health assessments we did not use techniques to pull the tortoise “out of its shell” so we could observe the head/facial region to conduct the health assessments as we considered it to be unnecessarily stressful to the animal. Results of observational health assessments, looking at variables that are considered to be potential clinical signs for URTD, are presented in Table 2. We see that potential clinical signs of URTD are approximately double for all variables in the steep slope plots compared to the flat plots. As it is possible for a tortoise to display one clinical sign and not another, these numbers only represent percentages of animals displaying each of the types of sign observed. In the flat plots, cumulative sign counts show that 11.4 % (n=4) of 35 animals that had full or partial observational health assessments showed one or more potential clinical signs of URTD. In the steep sloped plots 28.1 % (n=9) of 32 animals that had full or partial observational health assessments showed one or more potential clinical signs of URTD. Thus, observations of potential clinical signs of URTD were more than 2.4 times more likely in the steep slopes.

a.)



b.)



**Figure 13. Size class distribution for a.) Flat plots, and b.) Steep Slope plots. Size classes are based of mid-line carapace measurements (mm).**

**Table 2. Observational health assessments looking at variables that are considered to be potential clinical signs for URTD\*.**

	Flat Plots	Steep Slope Plots	Both plot types combined
Beak/nose wet	11.4 % (n=4 of 35)	18.8 % (n=6 of 32)	14.9 % (n=10 of 67)
Nasal exudates	13.6 % (n=3 of 22)	16.1 % (n=5 of 31)	15.1 % (n=8 of 53)
Breathing audible**	2.7 % (n=1 of 37)	6.9 % (n=2 of 29)	4.5 % (n=3 of 66)
Eyes***	7.1 % (n=2 of 28)	25.0 % (n=6 of 24)	15.4 % (n=8 of 52)

\*Not all variables could be observed on all tortoises therefore sample sizes differ

\*\*Assessment is if breathing is different from normal, e.g. whistle, labored, wheezy, etc.

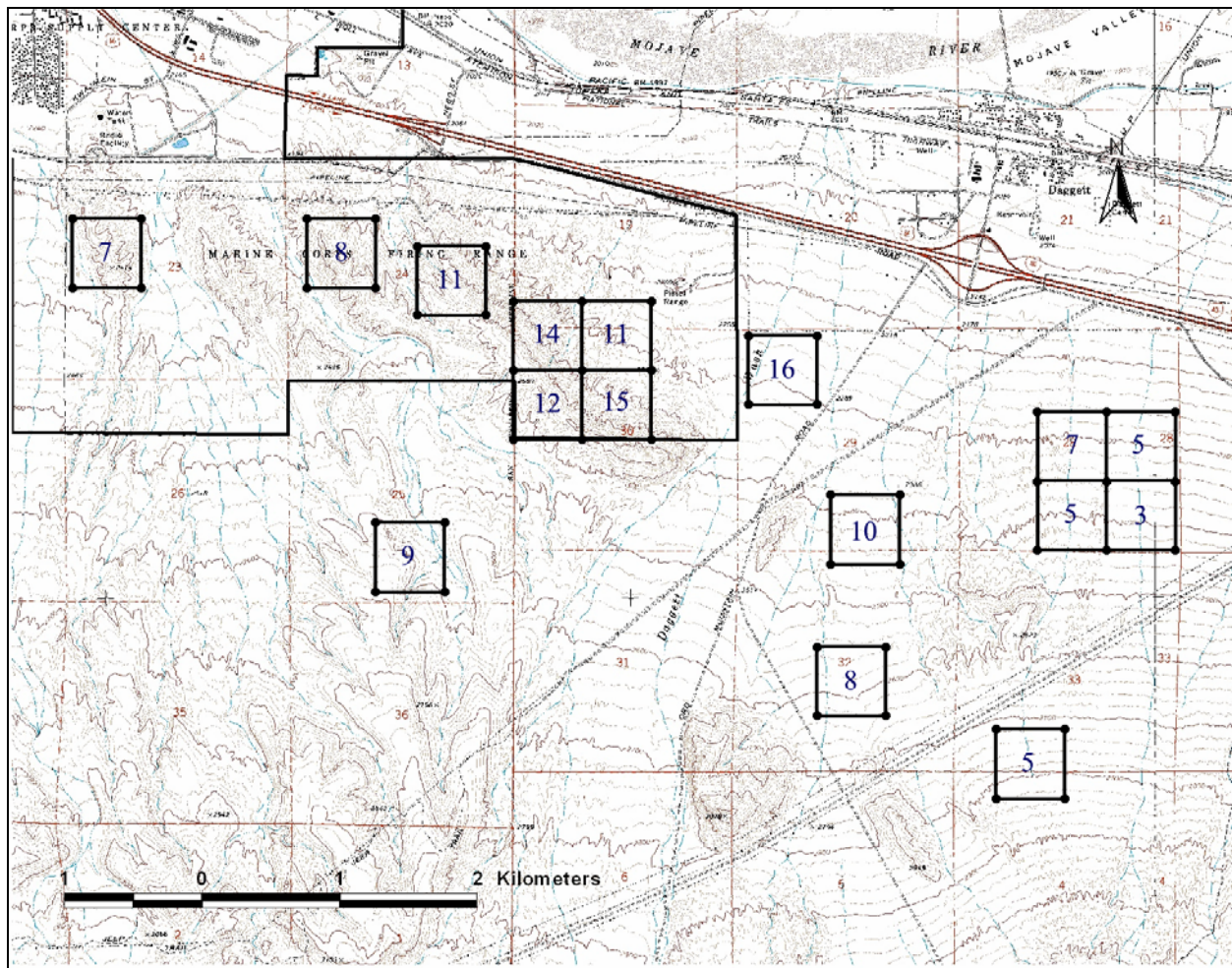
\*\*\*Looking for puffiness, palpebral edema, sunken eyes, mucous (wet or dried), moisture, etc.

### 3.2.4 Mortality on Plots

As with the transect surveys, numerous carcasses were observed on both plot types. The number of carcasses observed per plot is presented in Figure 14. Comparing the figure of carcasses to live tortoises (Figure 12), reveals that generally, more carcasses were observed than live tortoises. Making a comparative analysis of carcasses to live tortoises by plot type reveals that 25% of flat desert plots and 87.5% of steep slope plots had more carcasses than live tortoises. As we've already shown that population estimates of live tortoises do not differ between flat desert and steep slopes these results may be indicative of a greater population decline in steep slopes, however further analysis is warranted. Flat desert plots had an average of  $7.25 \pm 4.03$  carcasses per plot, with a range of 3-16. Steep slope plots had an average of  $10.88 \pm 2.70$  carcasses per plot, with a range of 7-14. These results are significantly different ( $U=12.5$ ,  $p<0.05$ ) therefore we can conclude that there are more carcasses in the steep slopes.

Carcasses were classified into "age" groups representing time since death as well as size classes. As there is a known bias in sampling efforts for small individuals the data needs to be parsed to include only animals greater than 180 mm MCL (sub-adult and adult size classes). An additional bias with small animals is that smaller carcasses have a greater probability of being totally consumed and/or carried away by a predator. Furthermore, the carcass aging keys were developed on adult carcasses, and it is currently unknown how, or if, they apply to smaller carcasses. The scale that is used for aging carcasses is crude and should only be considered an approximation, however, the oldest category is >4 years and can represent carcasses of any age. Removal of these carcasses from a data set gives you a picture of mortality over the past four (4) years. From a general demographic point of view what we see from all the data is that relatively equal numbers of males and females have died (Table 3, 4). In the flat plots, 34 % of the carcasses were sexed as females (n=17) and 36 % males (n=18) (Table 3), while in the steep

sloped plots 45.7 % were female (n=32) and 41.4 % (n=29) were male (Table 4). When the data is parsed to mortality only in the past 4 years we see a similar pattern with female carcasses in the flat desert plots representing 36.1 % (n=13) and 41.7 % (n=15) males (Table 3). While in the steep sloped plots 44.3 % were female (n=31) and 40 % were male (n=28) (Table 4). Thus, there does not appear to be any differential rates of mortality between the sexes in either the past four (4) years or looking at all carcasses. However, one should note that 30 % (n=15) of the carcasses in the flat plots and 24.7 % (n=20) in the steep slopes could not be positively assigned a sex due to the condition of the carcass.



**Figure 14. Number of carcasses observed in each plot. Data represents all carcasses observed including juvenile and immature size classes.**

There does seem to be some differences between the flat and steep sloped plots as to the timing of mortality, as well as a sex interaction. No carcasses in the flat plots were assessed to be less than one (1) year old, while four (4) carcasses in the steep slopes were of this age; furthermore all of them were male (Table 3, 4). Our next “time since death” age classification is 1-2 years. We find that in the flat plots, 13.9 % (n=5 of 36) of carcasses during the past four (4) years are in this age class, with a male to female ratio of 1.5:1 (Table 3). In the steep slopes, 28.6 % (n=20 of 70) of carcasses during the past 4 years are 1-2 years old with a male to female sex ratio of

1.71:1 (Table 4), which is not significantly different from 1:1 ( $\chi^2=1.316$ ,  $df=1$ ,  $p>0.05$ ). If we look at mortality in the past two (2) years inclusive in the steep slopes, we see that 34.3 % ( $n=24$  of 70) of carcasses during the past four (4) years are <2 years old, with a male to female sex ratio of 2.3:1 (Table 4), which is not significantly different from 1:1 ( $\chi^2=3.522$ ,  $df=1$ ,  $p=0.06$ ). Results for the next age class illustrate that from the flat plots, 86.1 % ( $n=31$  of 36) of carcasses in the past 4 year are in the 2-4 year old age class, with a male to female sex ratio of 1.1:1 (Table 3). The steep slopes have 65.7 % ( $n=46$  of 70) of carcasses in the past four (4) years in this age class category, with a male to female ratio of 1:2 (Table 4), which is significantly different from 1:1 ( $\chi^2=4.00$ ,  $df=1$ ,  $p<0.05$ ). Thus, in summary we observed that most of the mortality in the flat desert (83.8 %) occurred between 2-4 years ago, while a much lower amount (65.7%) occurred during that time frame in the steep slopes. The steep slopes had more mortality during the past 2 years (29.6%) than the flat plots (11.8%). Additionally, there was a non-significant trend for more male carcasses during the past two years in the steep slopes, with the opposite effect, significantly more female carcasses than males in the 2-4 year old age class. No such trend was evident in the flat plots.

**Table 3. Desert tortoise carcasses found on the flat plots separated by size class category, year(s) since death, and sex.**

Size Class (mm)	<1 year			1-2 Years			2-4 Years			>4 years			Totals
	Unknown	Female	Male	Unknown	Female	Male	Unknown	Female	Male	Unknown	Female	Male	
Subadult (180-207)					2	2	3	6	2	1	1	1	18
Adult 1 (208-239)							5	3	7	2	2		19
Adult 2 (>240)						1		2	3		1	2	9
Unknown size										4			4
Totals					2	3	8	11	12	7	4	3	50*

\*An additional 9 carcasses were omitted from this table as they were carcasses of juvenile and immature animals. The keys for sexing and aging carcasses were developed for adult carcasses and it is not known if smaller carcasses deteriorate at the same rate.

**Table 4. Desert tortoise carcasses found on the steep slope plots separated by size class category, year(s) since death, and sex.**

	<1 year			1-2 Years			2-4 Years			>4 years			Totals
Size Class (mm)	Unknown	Female	Male	Unknown	Female	Male	Unknown	Female	Male	Unknown	Female	Male	
Subadult (180-207)			1		3	4	2	5	3	3			21
Adult 1 (208-239)				1	3	4	5	13	1	4	1	1	33
Adult 2 (>240)			3		1	4	2	6	8	1			25
Unknown size							1			1			2
Totals			4	1	7	12	10	24	12	9	1	1	81*

\*An additional 6 carcasses were omitted from this table as they were carcasses of juvenile and immature animals. The keys for sexing and aging carcasses were developed for adult carcasses and it is not known if smaller carcasses deteriorate at the same rate.

### ***3.2.5 Historic populations***

By adding the population estimates for live tortoises to the number of carcasses less than four (4) years old we can get an idea of what the populations were like in the recent past and calculate rates of decline.

For the flat plots, the estimated live tortoise densities were 8.25 tortoises/plot. A total of 36 carcasses were aged to be less than four (4) years old (Table 5), or an estimated carcass density of 4.5 carcasses/plot. Table 5 presents individual plot estimates of live tortoises and carcasses that are less than four (4) years old. Therefore, the historic population density on the flat plots four (4) years ago is estimated to be 12.75 tortoises/plot. Therefore, in the past four (4) years, there has been an estimated average population decline in the flat desert plots of 35.3 % (9.09 – 66.67%) (Table 5).

For the steep sloped plots the estimated live tortoise densities were 5.88 tortoises/plot. A total of 70 carcasses were aged to be less than four (4) years old (Table 5), or an estimated carcass density of 8.75 carcasses/plot. Table 5 presents individual plot estimates of live tortoises and carcasses that are less than four (4) years old in the steep sloped plots. Therefore, the historic population density on the steep slope plots four (4) years ago was around 14.6 tortoises/plot. Therefore, in the past four (4) years, there has been an estimated average population decline in the steep slope plots of 59.81 % (28.57 – 83.33%) (Table 5).

**Table 5. Population estimates comparing flat plots to steep slope plots. Carcasses aged to be less than 4 years old per plot are presented as well as estimated historic densities with calculated percent declines during these past 4 years.**

	Estimated live tortoise	Carcasses <4 years old	Estimated tortoises 4 years ago	Percent decline
<b>Flat Plots</b>				
Plot 1	17	6	23	26.09
Plot 2	3	6	9	66.67
Plot 3	3	6	9	66.67
Plot 6	5	5	10	50.00
Plot 7	6	4	10	40.00
Plot 8	10	1	11	9.09
Plot 9	13	3	16	18.75
Plot 11	9	5	14	35.71
<b>Average flat plots</b>	<b>8.25</b>	<b>4.5</b>	<b>12.75</b>	<b>35.29</b>
<b>Steep Slope Plots</b>				
Plot 4	15	6	21	28.57
Plot 5	4	10	14	71.43
Plot 10	1	5	6	83.33
Plot 12	6	11	17	64.71
Plot 13	5	11	16	68.75
Plot 14	5	14	19	73.68
Plot 15	7	7	14	50.00
Plot 16	4	6	10	60.00
<b>Average Steep Sloped Plots</b>	<b>5.88</b>	<b>8.75</b>	<b>14.63</b>	<b>59.81</b>

## **4. DISCUSSION**

Results from this study have illustrated that there is a good sized population of desert tortoises inhabiting steep slopes at the MCLB and surrounding areas. In fact, there is no difference in tortoise densities calculated for the flat plots (“typical desert”) compared to the steep sloped plots. Furthermore, there is no difference in the physical characteristics of the tortoises between the two plot types. However, probably the most significant result of this study is the high rate of mortality that has been observed. The discussion will dwell mainly on this and potential reasons for these declines as illustrated through past studies. The study had two separate parts; the transect surveys and the study plots, we will address the results of the transect surveys first.

### **4.1 Transects**

The purpose of the transect surveys were to provide information as to relative densities of tortoises, as opposed to absolute densities. By sampling an area with transects and making all survey effort equal across a large area you are able to calculate utilization distributions which illustrate where the greatest probabilities (or densities) of a particular variable occur. We analyzed three (3) variables this way from the transect data; burrows active in the past year, live tortoises, and carcasses. The first two variables provide us with a general understanding of where the greatest densities of tortoises and tortoise activity are across the surveyed landscape. What we find is that the results are similar (Figures 9, 10), which is not overly surprising as we expect to find more burrows in areas with more tortoises. However, an additional reason for these parameters being correlated is that almost all tortoises observed during the transect surveys were observed in burrows. Part of the initiative behind this survey effort was to locate areas that may be best suited to future desert tortoise projects at the MCLB. As sample sizes are often an issue with desert tortoise studies it is preferable to find study areas with the greatest densities of tortoises. Therefore, if the MCLB was to conduct future research projects on their property it would be recommended that these studies be done in the areas of 20-50 % probability of encounter for the burrows and live tortoises (Figures 9, 10). As is illustrated in these figures, that area is approximately one kilometer due west of the pistol range buildings.

A large number of carcasses were observed while conducting the transect surveys. In fact, for every live tortoise observed, six (6) carcasses were observed (see figures 7, 8). Similar to the live tortoise and burrow distribution these carcasses were not distributed evenly, as can be seen in the utilization distributions in figure 11. The greatest densities of carcasses straddle the highest point on the MCLB moving in non-concentric rings towards the south. While this shows us where the greatest densities of carcasses are it does little to show us what the overall effects of the decline are. Once again, comparing figures 7 and 8 can give you an idea that some areas have declined more than others. Looking at the carcass data a different way, a ratio of live tortoises to carcasses observed provides similar results but shows the data in a different light. Not wanting to confuse the maps with two different types of grid systems (UTM and sections (as is presented on topoquads), we will refer to areas by sections. It does not matter that an entire section was, or wasn’t surveyed, as we are not looking at absolute numbers but ratios. The data for live tortoises to carcasses ratio by section is presented in Table 6. We present this data to show that from this simple transect style survey there is a 95 % mortality rate in sections 25 and 30, two adjacent sections. Sections 31 and 36 only had a portion of the section surveyed, 60 and

30 % respectively, however, no live tortoises were observed in these sections, which are directly south of sections 25 and 30. In contrast, 30 % of section 35 was surveyed and two live tortoises were observed and 3 carcasses. These alarming high rates of mortality in section 25 and 30 (and potentially sections 31 and 36) are more typical of an epizootic infection. These sections are adjacent to a road and power line right of way that may have provided access for the release of an ill pet tortoise from which the disease has radiated out. Such a statement is purely speculative as we did not survey south or east of the proposed survey areas (Figure 4), and therefore the utilization distributions (Figure 9, 10, 11) are somewhat shaped by the survey effort, i.e. 95 % will always be at the outer bounds of the survey area. It should also be noted that the greatest densities of live tortoise and burrows is adjacent to this greatest density of carcasses, towards the northwest. If the cause(s) of mortality are related to disease(s), and the disease(s) are contagious (which seems likely given the data), one would expect it to spread into this area of greatest density of live tortoises.

**Table 6. Live tortoise to carcass ratios, broken down by section.**

Section	19	23	24	25	26	30	31	35	36
Ratio	1 : 1.2	1 : 3.67	1 : 2.25	1 : 21	1 : 3.8	1 : 16	0 : 12	1 : 1.5	0 : 6

## 4.2 Plots

The results of the plot surveys show that there are few differences between the flat plots and the steep slope plots. This result is at first perplexing as desert tortoises in the Mojave Desert are considered not to live in steep slopes. However, it should be noted that the steep slopes at the MCLB are not solid rock, much as most large hills (and mountains) in the Mojave Desert are, rather the hills at the MCLB are primarily composed of the same medium to coarse graveled sands as the adjacent flat desert. Therefore, the substrate is suitable for burrowing and is of similar consistency to support the vegetation communities that desert tortoises are associated with including forage plants. It was not the purpose of this study to look at substrate types but future research across the desert tortoises range should examine substrate as a variable as it may be having a strong influence on where desert tortoises are distributed and possibly interacting with desert tortoise densities, i.e. an underlying variable in habitat suitability.

The most significant result from the plot surveys was the high rate of decline that has occurred in the past four (4) years. There has been declines in the adult population (MCL >180mm) of 35 % in the flat plots and 59 % in the steep sloped plots. Furthermore, the size structure of the remaining population in the flat plots is skewed towards large individuals, which is typical of populations that are showing low, or few, signs of recruitment. As desert tortoises are late to mature (15-20 years), this represents a lack of recruitment for a minimum of this time frame. Populations that exhibit such characteristics are often referred to as ghost populations or living dead. Assessing why a population has no recruitment is a difficult task and may prove more troublesome than at first it appears as there isn't a similar pattern in the steep sloped plots. Regardless, lack of recruitment is not what has caused the high rates of mortality in the past few years. It is suspected that the high rate of mortality is associated with disease. We saw higher rates of potential clinical signs of UR TD in the steep slopes as well as higher rates of mortality than in the flat plots. The health assessments that were performed were simple observational

assessments and thus are not conclusive of infection, nor where they performed by a veterinarian trained in chelonian diseases. However, desert tortoises rarely have wet beaks/noses unless they have been eating succulent vegetation or drinking, neither of which were possible during our surveys, and we observed almost 20 % of animals in the steep slopes to have wet beaks/noses, almost double that of the flat desert. Furthermore, nasal exudates are considered to be a strong indication of URTD in desert tortoises and 16% of tortoises assessed in the steep slopes had nasal exudates present. Thus, it seems likely, based on these simple health assessments for potential clinical signs of disease that URTD is present and has played a role in the mortality observed.

### **4.3 Desert Tortoise population decline literature review**

There are few peer-reviewed articles on desert tortoise population declines in the range of the desert tortoise. Turner et al. (1984) noted population declines in Ivanpah Valley of eastern California of 4.3% and 18.4% for 1980-81 and 1981-82, respectively. The most notable difference between the two years was that very little rain fell in the 1980-81 winter, leading into the 1981 study year, and there was virtually no production of annual plants. Additional declines of desert tortoises have been documented at two study plots in widely separated sites, the Desert Tortoise Research Natural Area (DTNA, western Mojave Desert) and Chuckwalla Bench ACEC (eastern Colorado Desert) (Berry, 1997). Reasons for declines at these sites appear to be from different causes. Tortoise populations at the DTNA declined by 76% overall (90% adult decline) in the thirteen years spanning 1979-1992. A large proportion of this decline was attributed to URTD infections between 1988 and 1992, with 1988 being the first observations of visible clinical signs of URTD at this or any other site in California. This pattern is typical of epizootic infection, which in this case seems to have been lethal. The severity of the disease was possibly exacerbated by drought conditions in 1989-1990 (Peterson 1994).

The study at Chuckwalla Bench noted a population decline of approximately 70% from 1979-1988 that was attributed to cutaneous dyskeratosis of unknown cause. Notable in the Chuckwalla Bench study was that there did not appear to be any further decline in the population between 1988-1992, contrary to observations at the DTNA (Berry 1997) and Ivanpah (Peterson 1994). In the eastern Mojave, Peterson (1994) documented a 41% decline (n=9 of 22) in his study population and believed that predation was a possible cause in only one of the nine mortalities, in fact, the other eight carcasses did not appear to have been even scavenged. Peterson (1994) found that most animals that died at this study site showed evidence of physiological stress prior to death and that the timing of the mortalities was coincident with a time of virtually no annual plants and lack of rain (1989-1990). Cause of death was attributed to drought-imposed physiological stress, essentially dehydration and malnourishment, as most of the mortality was observed after nearly 2 years of drought and food shortages. Disease did not appear to be a factor, as there were no visible signs of URTD observed, although tortoises with URTD may not necessarily exhibit gross symptoms (Jacobson et al. 1991).

More recently, a study in the eastern Mojave Desert in Nevada documented a decline in tortoise populations of more than 70% at one study area (Longshore et al. 2003). They provide evidence to support the conclusion that adult tortoise survival is dependent on annual precipitation and the concomitant annual biomass production. Longshore et al. (2003) documented low tortoise survival from 1996-1999 in areas with little to no annual vegetation present in 1996, 1997, and

1999, while a comparative study site during the same time period had more rainfall and much higher annual winter biomass and did not show any tortoise declines. The comparative results of their study led them to conclude that even relatively short-term drought and the subsequent lack of annual biomass can cause severe declines in tortoise populations.

The documented die-offs of most of these studies seem to be correlated with episodic short term drought conditions. Drought-like conditions, or at least years where little rain and few annuals would have been produced, coincides with most currently published tortoise declines. Karl (2004) analyzed data for study plots across the Mojave Desert for a 15-year period beginning in 1987, comparing densities from multiple years on each plot to local precipitation records for each plot. During this period, drought conditions occurred nearly every other year, with two to three back-to-back drought years (depending on location). With the exception of the Chuckwalla Bench and the Fremont Valley plots (where nearly half of the carcasses appeared to have been shot in the latter), all pulses of declines were coincident with drought. Drought was associated with increased mortality, especially of adult female tortoises, decreased reproduction, decreased recruitment, and increased age to maturity. What is alarming about the declines observed at the MCLB and surrounding area is that 3 of the past 4 years (2003, 2004, 2005) have been good years for rainfall and annual plant production, thus tortoises should be well hydrated and have had plenty of forage. However, 1999-2001 experienced drought like conditions and this may have caused physiological stress that weakened the animals, possibly making them more susceptible to disease outbreak, as has been speculated at the DTNA more than a decade ago (Peterson 1994)

A review of population decline would not be complete if predators were not considered and discussed. While Ravens are well documented to be predators of juvenile desert tortoises, very little has been published on other predators (reviewed in Boarman 2002). Carcasses found at Peterson's (1994) east Mojave site were typically intact, upright, and in a near normal posture. Peterson (1994) provides convincing evidence that all 10 carcasses he found at the DTNA in the west Mojave had been subjected to canid predators or scavengers. He noted that coyote tracks were present beside tortoise carcasses and some excavated burrows; furthermore he observed coyote scats containing parts of adult tortoises, and carcasses showed signs of canid predators or scavenging. All but one was found upside-down. Other research has suggested coyotes as a predator of adult desert tortoises (Luckenbach, 1982; Woodbury and Hardy, 1948; Berry & Woodman, 1984). Separating scavenging from actual predation is virtually impossible, although Peterson (1994) provide some evidence to support depredation. Berry (1997), working at the DTNA at the same time as Peterson (1994), reported a decline of 90% (61 tortoises/km<sup>2</sup> in 1988 to 6 tortoises/km<sup>2</sup> in 1992), noting that there were many fresh carcasses present. Peterson (1994) believed that his study animals were depredated, although the results of the study by Berry (1997) on mortality in the same area are more supportive of scavenging. It is unknown if carcasses at the MCLB and surrounding areas were depredated, scavenge, or neither.

#### ***4.4 Conservation and Management***

Human activities are considered to be a major cause of desert tortoise declines and loss of habitat (USFWS 1994b). The Desert Tortoise Recovery Plan (herein after "Recovery Plan;" USFWS 1994b) outlines a plan of action to manage desert tortoise populations to reduce mortality. The ultimate goal of these recovery actions is to achieve a stable or increasing population. The

Recovery Plan outlines several actions to reduce or eliminate the impact of human activities that may contribute to tortoise mortalities and general declines. Activities that the Recovery Plan stipulate should be prohibited in all DWMA's include (quoted from Recovery Plan, 1994b):

1. *All vehicle activity off of designate roads; all competitive and organized events on designated roads*
2. *Habitat destructive military maneuvers, clearing for agriculture, landfills, and any other surface disturbance that diminishes the capacity of the land to support desert tortoises, other wildlife, and native vegetation.*
3. *Domestic livestock grazing*
4. *Grazing by feral ("wild") burros and horses*
5. *Vegetation harvest, except by permit*
6. *Collection of biological specimens, except by permit*
7. *Dumping and littering*
8. *Deposition of captive or displaced desert tortoises or other animals, except under authorized translocation research projects*
9. *Uncontrolled dogs out of vehicles*
10. *Discharge of firearms, except for hunting of big game or upland game birds from September through February*

The Recovery Plan has been criticized for not having been fully implemented from both a management and scientific perspective. Due to the remoteness and the lack of military field training at the MCLB, all Recovery Team recommendations are being met, though this is not necessarily the case outside of the base boundaries. It is possible that tortoises could have been deposited at or near the MCLB (Management Recommendation #8), especially since an ORV recreation area is located to the south and an open access road, Ord Mountain Road, is available for access. This is purely speculative. None the less, simply applying the management recommendations of the Recovery Plan will not ensure stable or growing tortoise populations, even in remote areas where the recommendations are effectively implemented and were implemented prior to the Recovery Plan.

Desert tortoises tolerate huge changes in their body composition (Nagy and Medica 1986, Peterson 1996a, b, Henen 1997) and can have very low metabolic rates (Peterson 1996a, Henen et al. 1998). This combination of traits, combined with behavioral features, allows tortoises to withstand long periods without any water and food, such as occurs during drought conditions. Additionally, URTD has been shown to be exacerbated or induced by stress; therefore, die-offs attributable to disease (Berry 1997) may actually be because of drought-induced stressors coupled with URTD (Christopher et al. 1997, Karl 2004).

Drought-like conditions are a normal phenomenon in the Mojave Desert (Peterson 1994, Hereford 2002, Karl 2004) and drought conditions lasting 18 to 30 months are considered to be regular and something most Mojave Desert tortoises would be exposed to during their lives (Van Devender 2002). While population declines may have historically occurred, it seems unlikely that drought is the only factor in the dramatic observed tortoise declines during recent decades. I believe that the relatively recent invasion of the Mojave Desert by alien grasses and their use as a food plant may be causing a negative effect on desert tortoise nutritional status, exacerbating the stress of drought and resulting in the extreme tortoise declines we are seeing during drought conditions. Furthermore, it is also possible that global climate change has heated up the

environment just enough that the tortoises are active longer, thereby using up more of their reserves, hibernate at warmer temperature, thereby using up more of their reserves, and are thus unable to withstand the longer periods without food or water. A change in weather patterns, specifically the distribution and timing of rainfall, is predicted to occur as a result of global climate change. Therefore, it seems likely that there is a group of seemingly recent inter-twined changes that are having a negative effect on the desert tortoise resulting in large population declines.

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